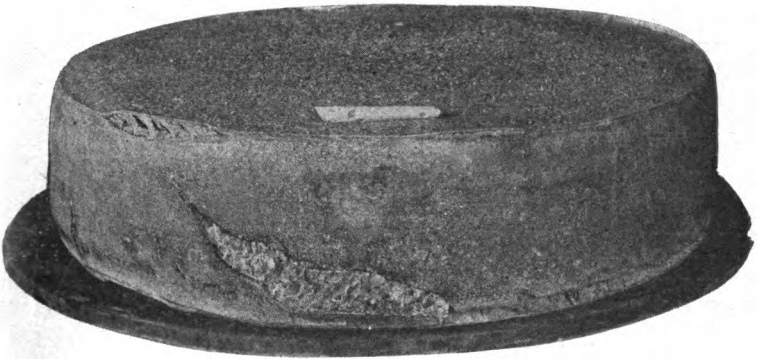
UNIVERSITY OF ILLINOIS
AGRICULTURE LIBRARY

ETIN No. 128 SEPTEMBER, 1905

Agricultural Library

UNIVERSITY OF WISCONSIN

Agricultural Experiment Station



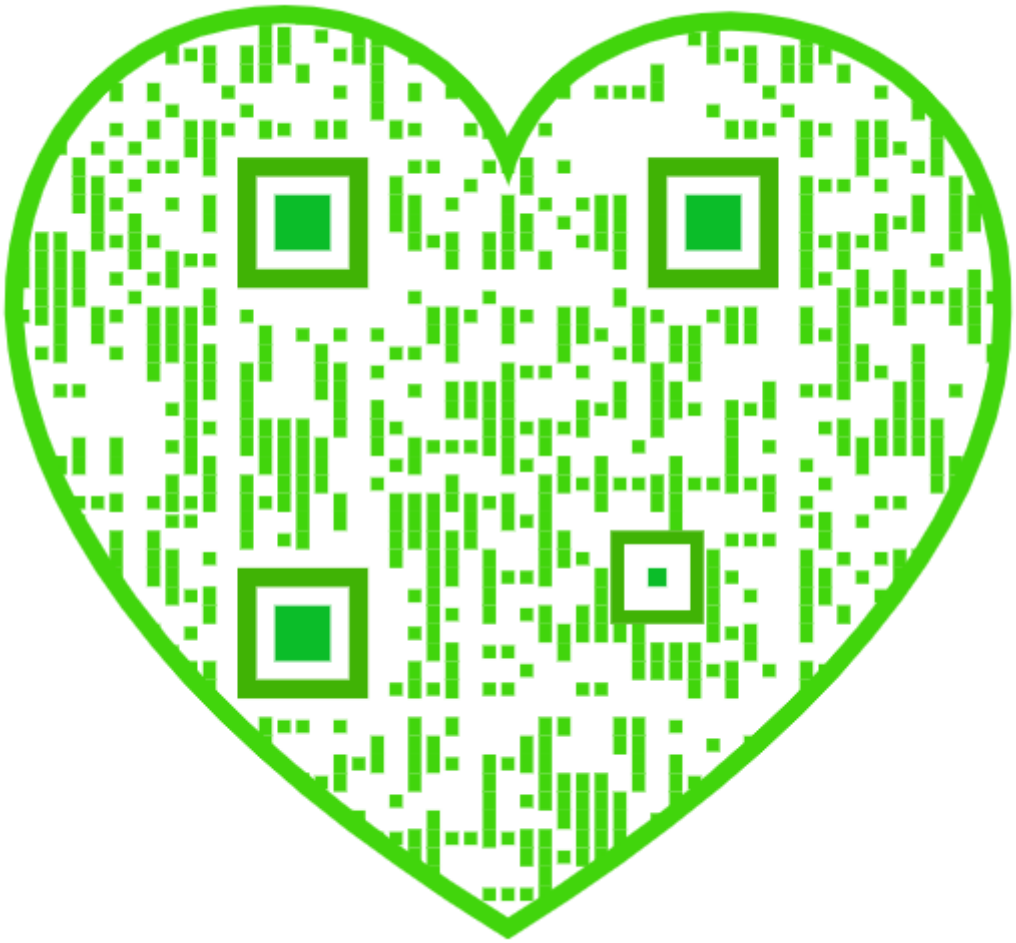
A Swiss cheese affected by this abnormal fermentation

A SWISS CHEESE TROUBLE CAUSED BY A GAS-FORMING YEAST

By

H. L. RUSSELL AND E. G. HASTINGS

MADISON, WISCONSIN



UNIVERSITY OF WISCONSIN

Agricultural Experiment Station

BOARD OF REGENTS

THE PRESIDENT OF THE UNIVERSITY, EX-OFFICIO.
STATE SUPERINTENDENT OF PUBLIC INSTRUCTION, EX-OFFICIO.
State-at-large, MAGNUS SWENSON, Madison; ALMAH J. FRISBY, Milwaukee.

District.	District.
1st. H. C. TAYLOR, Orfordville.	7th. EDWARD EVANS, La Crosse.
2nd. L. S. HANKS, Madison.	8th. EDWARD E. BROWNE, Waupaca.
3rd. DWIGHT T. PARKER, Fennimore.	9th. ORLANDO E. CLARK, Appleton.
4th. W. J. McELROY, Milwaukee.	10th. GEORGE F. MERRILL, Ashland.
5th. ARTHUR J. PULS, Milwaukee.	11th. AUGUST J. MYRLAND, Grantsburg.
6th. M. C. MEAD, Sheboygan.	

OFFICERS OF THE BOARD OF REGENTS

M. C. MEAD, PRESIDENT. E. F. RILEY, SECRETARY, Madison.
H. C. TAYLOR, VICE PRESIDENT. STATE TREASURER, Ex-Officio Treasurer.

AGRICULTURAL COMMITTEE

REGENTS PARKER, TAYLOR, CLARK, MYRLAND, BROWNE, AND PRESIDENT VAN HISE.

OFFICERS OF THE STATION.

THE PRESIDENT OF THE UNIVERSITY.
W. A. HENRY, DIRECTOR.
S. M. BABCOCK, ASSISTANT DIRECTOR AND CHIEF CHEMIST.
E. W. WOLL, CHEMIST.
H. L. RUSSELL, BACTERIOLOGIST.
E. H. FARRINGTON, DAIRY HUSBANDMAN.
A. R. WHITSON, SOIL PHYSICIST.
E. P. SANDSTEN, HORTICULTURIST.
R. A. MOORE, AGRONOMIST.
GEO. C. HUMPHREY, ANIMAL HUSBANDMAN.
A. S. ALEXANDER, VETERINARIAN.
G. N. KNAPP, AGRICULTURAL ENGINEER.
D. H. OTIS, ANIMAL HUSBANDMAN.
E. G. HASTINGS, ASSISTANT BACTERIOLOGIST.
C. W. STODDART, ASSISTANT SOIL PHYSICIST.
W. S. BROWN, ASSISTANT IN HORTICULTURE.
J. C. BROWN, ASSISTANT IN AGRICULTURAL CHEMISTRY.
GEO. A. OLSON, ASSISTANT IN AGRICULTURAL CHEMISTRY.
J. G. FULLER, ASSISTANT IN ANIMAL HUSBANDRY.
C. A. OCOCK, ASSISTANT IN AGRICULTURAL ENGINEERING.
A. L. STONE, ASSISTANT IN AGRONOMY.
G. H. BENKENDORF, ASSISTANT IN DAIRY HUSBANDRY.
J. G. MOORE, ASSISTANT IN HORTICULTURE.
E. R. JONES, ASST. IN SOILS, DRAINAGE, AND CRANBERRY INVESTIGATIONS.
LESLIE H. ADAMS, FARM SUPERINTENDENT.
IDA HERFURTH, EXECUTIVE CLERK.
SOPHIE M. BRIGGS, LIBRARIAN.

FARMERS' INSTITUTES

GEORGE McKERROW, SUPERINTENDENT.
NELLIE E. GRIFFITHS, CLERK AND STENOGRAPHER.

Telephones to Station Offices, Dairy Building, and Farm Office.

The bulletins and annual reports of this Station are sent free to all residents of the state upon request.

N75L
no. 128
cop.

A Swiss-Cheese Trouble Caused by a Gas-Producing Yeast.

H. L. RUSSELL and E. G. HASTINGS.

The very rapid development of the manufacture of Swiss cheese in this state makes this industry an important factor in Wisconsin dairying. In the making of this type of cheese, the method of handling the milk is materially different from that practiced in cheddar cheese manufacture, and, in some respects, more abnormal fermentations are likely to be encountered, that often prove a source of serious loss. In large measure these defective cheese (seconds, gläsler, nissler, etc.,) are due to bacterial fermentations, often of a gas-producing nature. These organisms, if present in the milk through careless methods of handling, are able to develop luxuriantly during the making of the cheese, by reason of the fact that in Swiss cheese but little acid is formed. In American (cheddar) cheese the acid developed in the process of manufacture keeps the gas-forming organism to a greater degree in subjection, and hence less trouble of this nature is experienced in this type of cheese than in that made by the sweet curd process.

SEVERE OUTBREAK OF "GASSY" FERMENTATION IN SWISS CHEESE.

During the last year a defective condition in Swiss cheese was brought to our attention that was of such a serious nature that the outbreak was thoroughly investigated from a bacteriological point of view. The trouble occurred in one of the best factories in the Swiss cheese district, the Runrood factory, in Iowa county, three miles northeast of Gratiot. The factory

operator, Mr. Alex. Rolli, was an old, experienced maker, who had always had the reputation of being one of the best makers in this region. The trouble began in May, appearing occasionally until July, when it was very bad for a time. The difficulty then disappeared, only to break out in August with greater severity than ever.

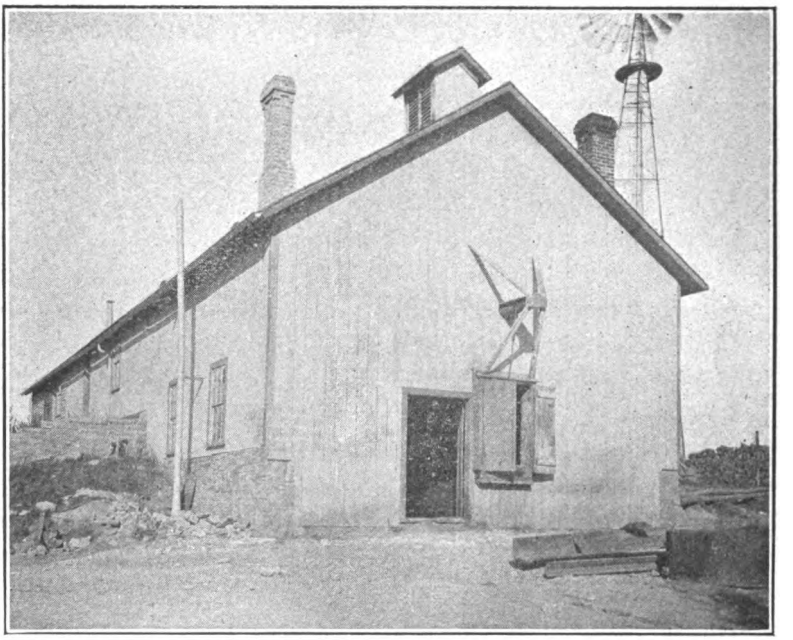


FIG. 1.—View of Rumrood factory near Gratiot, Wisconsin, where the cheese trouble occurred.

EFFORTS TO OVERCOME DIFFICULTY.

The maker used every possible effort to locate the cause of the trouble. He had changed his rennet supply several times, using natural rennets obtained from other factories, also the commercial rennet extract (Hansen). The brine tank had been cleaned out and a fresh solution made, but all to no effect. At the beginning of the season, the customary whey barrels were in use, but these had been discarded at the request of the state dairy commission inspector, and a new whey tank installed. The factory was visited several times in the course of the season

by dairy inspectors, and curd tests were made of the milks supplied by each patron, and every possible condition investigated, but in no case was any clue observed that threw any light on the trouble.

At this juncture, late in September, two samples of the affected cheese were submitted to the experiment station for examination. Bacteriological cultures made from these failed to reveal any gas-producing organisms. In October the factory was visited by us, and a clean condition in general was found.

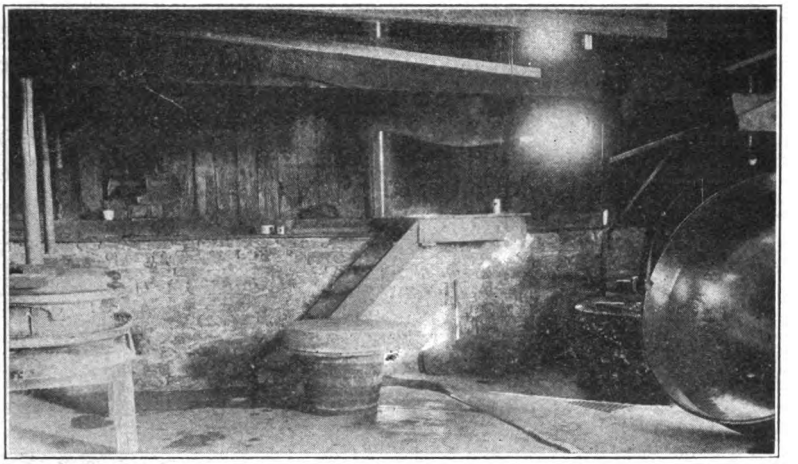


FIG. 2.—Interior view of Runrood factory. Cheese kettle on right, cheese press on left, a large drum Swiss cheese just removed from press in middle.

The floor of the factory was of cement construction, and the general interior of the building and the utensils were satisfactory. The water supply was drawn from a well 200 feet deep, and was stored in a small tank just outside of the building. The new wooden whey tank which had been earlier installed in place of the whey barrels was found in a clean condition.

In the factory it was found that the reprehensible practice was followed of holding the whey in wooden vats for 24 hours to allow of the creaming of the butter fat. The Swiss makers claim that the whey must undergo this souring change in order to cause a more ready and complete separation of the cream, but the conditions which are produced where this practice is

followed are such as are ideal for the growth of certain undesirable organisms which, as we shall show later, are the cause of this trouble. At the time of our visit to the factory, it was noted that the whey in the whey vats was undergoing a violent fermentation.

Bubbles of gas were continually rising to the surface and breaking through the cream layer. The cream was skimmed from the surface of these vats and placed in a tin vat, pending the collection of a sufficient quantity for churning. An examination of this sour whey cream showed the presence of an active fermenting agent, as there was fully six or eight inches of frothy cream on the surface. This material had at this time a decidedly yeasty odor, which could be readily perceived. It was quite evident therefore from these findings that the trouble in question was associated with this condition. Before detailing further the proof of this proposition, the character of the fermentation in the cheese will be described.

FIG. 3.—Side view of drum Swiss cheese, showing cracking of cheese.

NATURE OF AFFECTED CHEESE.

The defective condition here referred to does not appear while the milk is being worked up into cheese,* nor immediately after they are taken from the press. The first abnormal condition is generally noted in the brine tank. When placed therein the

*Mr. Rolli says however he usually has a poor cheese whenever he gets a "white" whey.

cheese do not seem to absorb salt in the usual way, this condition doubtless being due to the absence of those normal ripening changes which are associated with the breaking down of the casein. The first most evident symptom of trouble usually appears when the cheese have been on the shelves for a week or so. The edge of the cheese cracks or opens, generally near the junction of the top or bottom and the side. (See figure 3; also frontispiece). This split continues to increase in length, running around the circumference of the cheese, and in severe cases the interior of the curd may be forced out through this crack.

FIG. 4.—Top view of drum Swiss cheese, showing rupture of surface at several different points.

In figure 5 this stretching of the plastic curd toward this opening is well shown. This is of course due to the pressure of gas within the cheese. Relief from this pressure occurs at this point because resistance is less here than elsewhere. Sometimes the cheese "huff" without splitting in this way, but generally they do not show marked evidence from the outside. Usually the cheese have a poor texture, remain tough and rubbery, even when of considerable age. When a plug is drawn or the cheese is cut, the gaseous fermentation is usually very evident. The texture shows abundant gas holes of varying size. These are

always more numerous than are to be found in a normal No. 1 Swiss. Sometimes cheese are found that split open on the edge and still show a solid body. In all cases, however, the flavor is decidedly off, a disagreeable sweet taste being observed. The affected cheese are also usually off in color. Very gassy cheese are badly bleached. Neither do the cheese seem to have the usual degree of acidity.

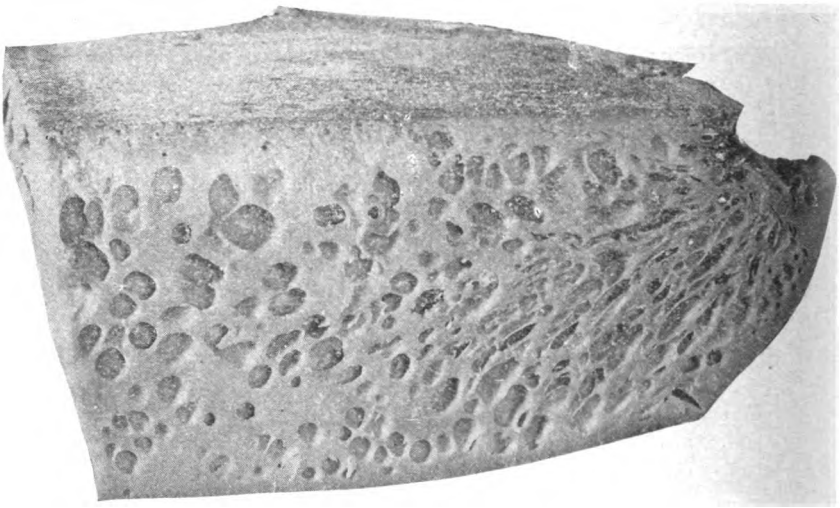


FIG. 5.—Section of affected cheese, showing the crack at junction of side and top. Note the movement of the plastic curd toward this opening, as shown by the peculiar shape of the numerous gas holes.

A curious feature is sometimes noticed in the large drum Swiss cheese, in that only a portion of the same will be affected, while the remainder is perfectly sound. The intensity of the trouble above described fluctuated greatly. Some of the cheese made from one batch of milk were very bad, while that of the next milking would be all right.

AMOUNT OF LOSS.

The aggregate loss in the case of this single factory was several thousand dollars. This trouble began in May and lasted, with intermissions, until the factory closed in October. During this time the amount of milk handled daily was from four to

five thousand pounds. In October, when we visited the factory, about 3,100 pounds were being handled. During the season over two tons of cheese was utterly ruined and had to be thrown away, while a large proportion of the balance of the make was injured to a greater or less extent, the cheese being sold for anything it would bring. The maker bought the milk outright, and the loss, which he estimated at over $2,000, consequently fell entirely on him.

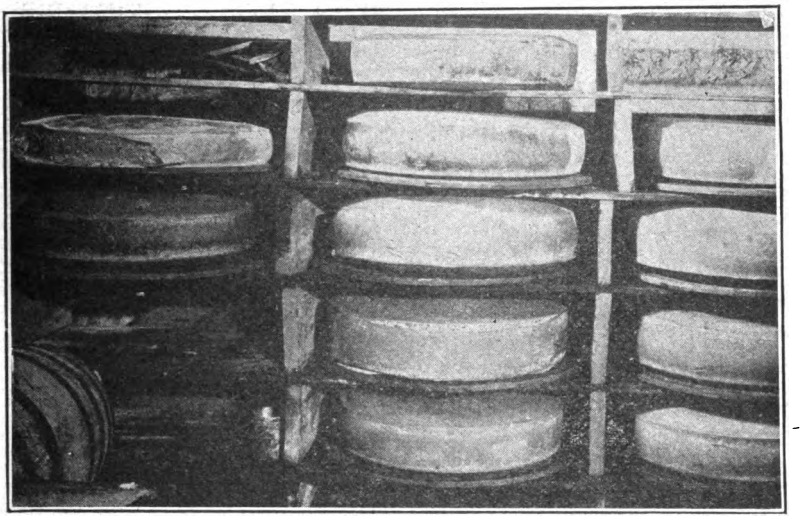


FIG. 6.—View in cheese cellar, showing affected cheese in different stages of development. Note the cut surface of cheese in upper left corner, showing gassy condition. Some of the affected cheese are "huffed," others split or cracked on edge.

BACTERIOLOGICAL EXAMINATIONS.

A number of the affected cheese, also samples of milk from the individual patrons, whey from the kettle, whey vats, drip boards and rennet jars were subjected to bacteriological examination. The results of these examinations were as follows:

In the samples of whey taken from the whey vats used to recover the cream, yeast cells were found in abundance, but no gas-forming bacteria. Also the same yeast organism was found in the rennet jars. The samples taken from the kettle showed this type of organism to be sparingly present, but the samples

of cheese did not reveal this kind of germ life. Cultures made with this yeast in milk or whey showed that this germ was capable of fermenting milk sugar, causing the formation of large quantities of gas. Ordinary yeasts, such as beer or bread yeast, are unable to decompose sugar of milk, but this yeast possesses this property, and is therefore a dangerous organism, if it is commonly found in milks. The samples of milk from the individual patrons were thoroughly examined, and while gas did not develop abundantly in the fresh samples, such fermentation set in when samples were kept several days until they had soured. From these old milks, yeasts capable of fermenting milk sugar were found in the case of all patrons but one. This condition is not at all surprising when one considers that the sour whey, rich in these germs, is taken back to the farm in the same set of cans that is used to bring the fresh milk. The process of cleaning the cans at the farm is never so thorough as to completely destroy the obnoxious germs. Therefore, in a short time organisms of this type become distributed throughout the whole region. In the whey butter which was made in this factory a yeasty taste could be easily recognized. The same prevalent germ was readily recovered from the butter upon examination. It is rather peculiar that they were so sparsely found in the cheese made from the affected milk, but evidently the conditions here are not especially favorable for their growth, or the retention of their vitality.

ORIGIN OF THE TROUBLE.

With fermentation of this character there is always a great difference of opinion as to what causes the trouble. The cheesemaker is very apt to lay the blame on the farmers, and say that they do not give proper care to the handling of the milk on the farm.

The farmers, on the other hand, charge the trouble to the carelessness of the maker and the dirty condition of the factory. When these customary charges and countercharges fail to have the desired effect in overcoming the trouble, insinuations as to "doped" and "doctored" milk are not infrequently offered as explanatory of an imperfectly understood phenomenon.

Now, as a rule, the majority of troubles of this character are brought about in large measure by ignorance of the effect which certain conditions may produce. Tainted conditions in milk and dairy products are usually attributable to the growth of living organisms that gain access to the milk in one way or another. By reason of the fact that the milk is not properly handled, these germs are given opportunities for development, and often such growth is so abundant as to result in the production of bad flavors. It is essential in studying any abnormal fermentation of this character that the true or exciting cause be first located, but at the same time to place these scientific findings on a basis where the results can be applied in commercial practice, it is also necessary to point out the influence which surrounding conditions may have on the growth of the germ in question. The disease, consumption, cannot be produced unless the bacillus of tuberculosis is present, but it is equally important to know that certain conditions of our environment may predispose our systems—prepare the soil as it were, for a more ready acceptance of the germ. Thus, in attempting to control any of these abnormal fermentations in the dairy, not only must one seek for the real cause, but we must also find out the condition which permit the germ in question to find its way into milk or to develop so luxuriantly therein.

CAUSE OF THE TROUBLE DUE TO A GAS-FORMING YEAST.

Conclusive proof that this yeast germ separated from the samples of whey, milk, etc., is the real cause of the abnormal fermentation here described is afforded by the following experiment made under our direction by Mr. Fred Marty, now inspector of the State Dairy and Food Commission:

Six hundred and fifty pounds of milk were taken and to it were added about 4 pounds of boiled whey that had subsequently been inoculated with this yeast. This starter when added was fermenting vigorously. The milk showed no signs of abnormal condition during manufacture, and when the curd was put to press, no evidence of gas had developed. By the next morning, however, a most violent fermentation had occurred, the green

curd being forced out of the hoops and looking like a pan of dough allowed to stand too long. A plug taken from the cheese showed a very gassy condition throughout the whole body. Two weeks later the cheese was tough and rubbery and did not seem to take the salt well. In flavor the cheese resembled those previously described in connection with the trouble at the Gratiot factory. Even after several months' curing, the cheese was insipid and decidedly lacked flavor.

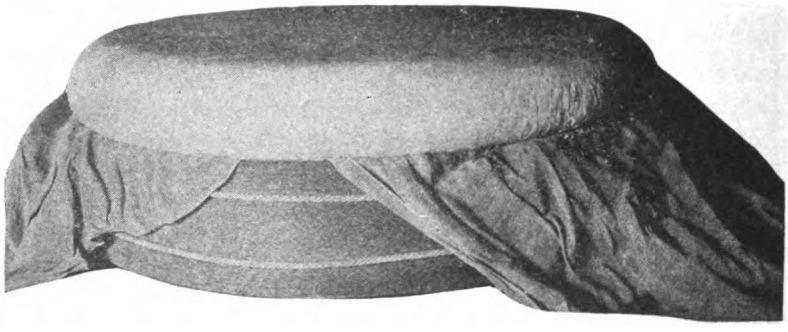


FIG. 8.—Drum Swiss cheese made at the U. W. Dairy School by Mr. Fred Marty. Milk was inoculated with yeast starter. Photograph taken 24 hours after cheese was made. Press board removed and the curd mass rose above sides of press hoops like a pan of dough.

There is absolutely no question but that the real cause of this trouble lies in the fact that in some way the yeast organism here described gains access to the milk and is thus incorporated in the cheese. Working on the sugar in the milk, it causes the formation of carbonic acid gas and alcohol together with certain more or less objectionable flavors. But when we have answered the question in this way, we have only given a partial answer. The practical cheese-maker may possibly be interested in the fact that the trouble in question is really due to a milk sugar splitting yeast, but he is very much more interested if the scientific student will tell him how this yeast germ gets into his milk and how he can prevent it, if possible. There the several methods in use in Swiss factories that serve as a loop hole for the entrance of this undesirable germ and if the factory operator is shown how these methods may affect the growth of the yeast he may be able to avoid the loss incident to these changes. Before

discussing the influence of these methods, a few facts* in regard to the germ in question, as to conditions which favor or retard its growth, may be helpful.

CHARACTERISTICS OF THE YEAST ORGANISM.

Nature of the Organism.—Most fermentative organisms that affect milk belong to the bacteria, but this germ belongs to the budding fungi, the yeasts. The action of yeast is well known in the raising of dough in bread making, and the production of alcohol and carbonic acid gas in malted liquors. All yeasts require sugar solutions for their rapid growth. The ordinary yeasts, (bread and beer yeasts) are unable to ferment sugar of milk, but act mainly upon glucose, maltose and saccharose (cane or beet sugar), but in the case of this yeast, the milk sugar is rapidly decomposed, alcohol and carbonic acid gas being formed.

Conditions Favoring Growth.—Where sugars of any kind (milk, cane or glucose) are present, this germ can grow, but in liquids containing milk sugar, growth is especially abundant. Reproduction is very much more rapid at or about blood heat (98° F.) than at lower temperatures. This fact is of importance in explaining why troubles of this character are much more apt to develop in the hot summer season than when cooler. A study of the food conditions favorable for the growth of this germ shows that the chemical reaction of the milk or whey is the most important factor in determining the rate of development. Yeasts in general are able to develop in strongly acid solutions and this type of yeast is no exception to the general rule. In fact, it grows abundantly in old, sour whey, or milk, where the acidity is so high as to check practically all bacterial growth. In this way this yeast germ becomes abundant in such samples, although an examination of fresh milk or whey may not have revealed any or only slight traces of the germ.

Retention of Vitality in Dried or Moist Condition.—The question as to the length of time this germ retains its vitality in a dried condition is of moment as the whey containing the or-

*Fuller discussion of the life history of this organism is reserved for the Annual Report.

ganism dries on the floor or walls of the factory. Direct experiments on this point have been made and it has been found that the germ in a dried condition is capable of living for at least four months so there is abundant opportunity for the organism to be carried over from one season to the next. In old milk or sour whey, vitality is retained for several weeks. It is a curious fact though that the vitality of this organism in cheese is much shorter. We have found it without difficulty in new cheese or even after the lapse of a couple of weeks or so, but in Swiss cheese several weeks old up to three months, it has been impossible to demonstrate the presence of live yeast cells, even where the cheese was richly inoculated with the same at the outset. Some conditions seem to prevail here which cause a much more rapid death of the cells than occur in the milk or whey.

Temperature at which Germ is Destroyed by Heat.—Heat is the best agent for the destruction of most types of germ life, and for most bacteria that are not able to form spores, a temperature of 140° F. for 10 minutes is sufficient to destroy their vitality. In the cooking of the curd in Swiss cheese making, a much higher temperature (132° F., or 44° R.*), is used than in making American cheese, and it might be thought that a longer exposure to this heat would actually destroy the germs in the milk.

The following experiment was made on cultures of this yeast germ in whey to see if it could withstand the heat of the cooking process:

Exposure of Yeast Organism to 132° F.

15 min.	20 min.	25 min.	30 min.	35 min.
+	+	+	+	+

+ = growth.

Even after 35 minutes' exposure the germ grew vigorously indicating that it will not be destroyed in the manufacture of the

*The Swiss makers in Wisconsin commonly use the Reaumur temperature scale, which is the standard in Switzerland and France.

cheese. A scalding temperature of 150° F. will, however, destroy the vitality of the organism in ten to fifteen minutes, so that it is possible to kill out the same in a factory even though no steam is at hand. The exposure, however, must be for the period mentioned, and not merely for a moment or so.

Experiments made where the organism was dried on slips of paper and exposed to the action of streaming steam show that an exposure of fifteen seconds suffices to kill the same. Of course, not many factories are provided with an equipment which permits of the generation of steam, but where such conditions do obtain, it is a very easy matter to control the purity of all utensils, such as kettles, vats and other pieces of apparatus.

Action of Chemical Disinfectants.—Frequently the action of chemical disinfectants will enable the factory operator to destroy the life of organisms that are a source of trouble in the factory. Experiments were made with soda solution, chloride of lime, formalin and corrosive sublimate. The results obtained were as follows: Corrosive sublimate (1 part of the salt to a 1000 parts of water) killed the yeast in a period of five minutes. The chemical action of this strong disinfectant on metallic surfaces and its highly poisonous nature limits its use, however, in the factory. Formalin (2.5 parts of the commercial solution to 100 parts of water) is usually recognized as a desirable disinfectant, but with the exposures made with this strength of solution, growth of the yeast was obtained even where cultures of the organism were exposed for twenty minutes. Chloride of lime (3% solution) was destructive after five minutes exposure while a 2% soda solution at 122° F. was effective in even a shorter period of time. The harmlessness of soda, its cheapness and ease of application probably renders this chemical the most suitable for general factory disinfection. A thorough application of a hot soda solution can be made with ease to all interior surfaces, as walls, floors, etc., as well as to vats and other utensils.

PRACTICES FOLLOWED IN SWISS CHEESE FACTORIES, WHICH AID IN THE DEVELOPMENT OF THE YEAST ORGANISM.

From what has been given of the conditions which favor the rapid growth of this germ, it appears that old whey furnishes a most suitable medium for its development. Wherever conditions prevail which permit of the retention of this material, one is likely to find that these yeasts will develop in large numbers.

There are three methods in most Swiss cheese factories which are more or less undesirable because they allow of the retention of at least a portion of the whey for a considerable period of time, and consequently give a favorable opportunity for the development of these obnoxious organisms. These methods are as follows:

1 Holding the whey until it sours so as to allow the butter fat to be skimmed off, sometimes known as the "cold process" of recovering the butter fat.

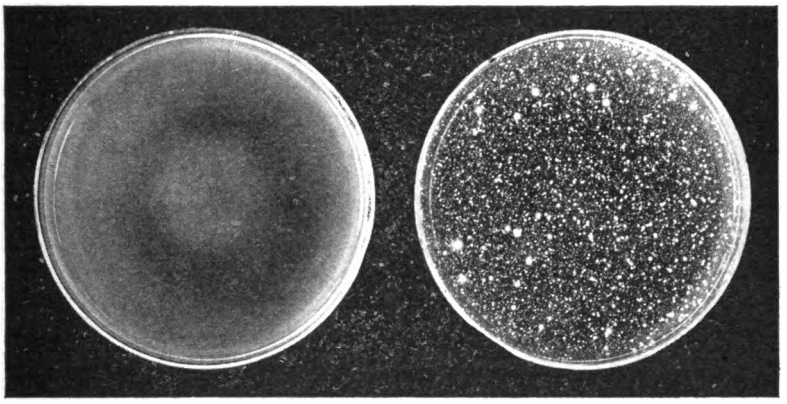
2. Soaking the rennets in whey and using this solution of rennet extract for the curdling of the milk.

3. The barrel method of whey disposal to the farmers.

1. CUSTOM OF HOLDING THE WHEY UNTIL SOUR TO RECOVER THE BUTTER FAT FOR WHEY BUTTER.

The method formerly in use by which the butter fat was recovered from the whey in order to make whey butter, was to heat the whey to a scalding temperature. When the whey was so treated, the butter fat collected on the surface and could be readily removed in a short time. Under these conditions the germ life in the whey was more or less completely destroyed. More recently, the custom has been introduced of holding the whey in wooden vats for 24 hours after it has been taken from the kettle. With the souring of the whey it is claimed that the cream rises more rapidly. Sometimes to the fresh whey is added a quantity of sour whey so as to hurry the development

of acid. Under these conditions the whey is kept in the factory for 24 hours before it is returned to the farmers. The result is that this sour by-product is in an advanced state of fermentation. It has previously been shown that this acid liquid is just the ideal medium for the growth of yeast-like organisms. In this material they will develop even faster than in milk, because the acidity is so high as to hold in check many of the bacteria.



A B

FIG. 8a.—Culture plates, showing germ content of whey treated by (a) the hot process, and (b) the cold process, for recovery of butter fat. These samples were taken from the same factory where they use the cold process of allowing the night's whey to stand in a tin vat for the cream to rise, and the hot process of boiling the morning's whey and immediate skimming of the butter fat. The two cultures contain the same amount of whey. In "a" the yeasts have all been killed by the heating process; in "b" each spot shows a colony of yeast germs that have developed from the organisms in the sour whey. Is it any wonder that the easier process of removing the butter fat from the cold whey is more likely to introduce undesirable fermentative organisms?

If, therefore, any yeast organisms whatever exist in the whey to start with, they rapidly develop in this sour liquid until they become very abundant. The consequence is that the whey tank kept for this purpose becomes fouled with such undesirable germ life. Day after day this growth is propagated, as the old whey is drawn off and fresh liquid added to the tank. Sufficient seed always adheres to the sides of the vessel, (if it is not actually added in the form of some sour whey) to start the fermentation anew, so that abnormal growth may continue for a longer or shorter period of time, depending upon temperature conditions, thoroughness with which the tank is cleaned, etc.

That this factory method of treating the whey offered conditions favorable for the growth of the yeast in this case was very evident from the appearance of the whey tanks on the occasion of our visit to the Gratiot factory. The cream layer on the surface of the whey in these whey vats showed a most active state of fermentation by the bubbles of gas rising to the top, and the vat of cream that had already been skimmed was covered with yeasty-smelling froth to the depth of several inches.

2. USE OF WHOLE RENNETS SOAKED IN SOUR WHEY.

Another place for the luxuriant development of the yeast germ is found in the jars in which the whole rennets are soaked to extract the active rennet used in curdling the milk. In most Swiss factories the natural or whole rennets are used instead of the commercial rennet extract. These dried rennets are soaked in whey for 24–36 hours previous to using. The jars used in this work are generally placed in a warm place, as on the back of the fire place, so as to hasten the extraction of the rennet. No better conditions could be provided for the development of the yeast organism, if the whey is originally infected. We have made examination from different factories and found that the milk, and the whey in the kettle were free from these yeasts, and even the whey in the whey tank outside contained only a small number, but, at the same time, the whey solution in the rennet jar contained them in great abundance. Such rennet extract, contaminated in this way, is simply adding a starter of the worst possible kind to the milk. There is no question but that this custom is not infrequently responsible for the development of trouble of this sort. In the case of this factory the yeasts were found in great abundance in the liquid in the rennet jars. Also a similar case has come under our observation in a recent outbreak in a factory near Darlington making block Swiss cheese. The cheese in this factory underwent this splitting type of fermentation, cracking open often for nearly the whole length of the cheese. This factory was recently inspected by one of the State Dairy and Food Inspectors, Mr. F. E. Carswell, and he became convinced that the trouble in

question was due to an infection which was introduced with the rennet solution prepared in the way above described. He recommended the maker to change his rennet and use the commercial

FIG. 9.—Block Swiss cheese from Darlington factory, showing crack along side of cheese through which the fresh curd has been forced out.

extract instead of the whey soaked rennets. After this change was made, no further trouble was experienced with the cheese, although previous to this time practically all of the cheese made had been injured. Some of these affected cheese were sent to

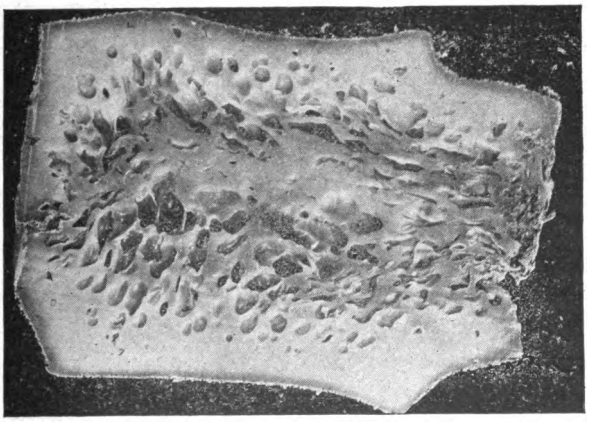


FIG. 10.—Section of block Swiss cheese, showing crack on right side. The curd mass on these cracked edges molds and spoils quite readily. The outer white layer absorbed salt in abundance, but affected inner portion would not take up salt.

the laboratory for a bacteriological analysis and the same type of yeast cells were found is in the trouble at the Gratiot factory. These findings, together with the general character of the

trouble described, leave no doubt as to the identity of this abnormal fermentation with the one here referred to as occurring in drum Swiss cheese.

3. THE BARREL METHOD OF WHEY DISPOSAL.

The custom of placing the whey in individual barrels for the farmer to remove and carry back to the farm, is a custom that is the cause of much of the trouble with which the Swiss cheese industry has to contend. Such receptacles are rarely, if ever, entirely emptied of their contents so that the quantity of whey remaining from day to day serves to inoculate the fresh whey with all kinds of fermentative organisms capable of thriving under such conditions. This old whey left in the barrels develops the necessary acidity to give proper conditions for the growth of the yeast germ, but if the whey is first held in the factory for twenty-four hours to allow it to sour before it is placed in the disposal barrels, the conditions are even more favorable for yeast development. This material taken back to the farms in the same set of cans that are used to bring the fresh milk readily permits of the infection of the fresh, sweet milk unless great care is used in cleaning the milk cans. On the farm steam is not at command, and it is much more difficult to rid the cans of such a contamination. In such a way as this, undesirable organisms may be spread throughout a region where the farmers take their milk to a factory once infected in this way. Such was the conditon at the Gratiot factory at the close of last season's work. Practically every farmer's dairy was more or less infected with this yeast as was shown by an examination of the individual milks.

PRACTICAL SUGGESTIONS THAT WILL OVERCOME THE ABNORMAL FERMENTATION.

From a consideration of the foregoing methods, there is no escape from the conclusion that the customs practiced in the Swiss cheese factories are in large measure responsible for the trouble. While the care of the milk on the farm is of great importance in determining the quality of the product made, yet in this particular type of abnormal fermentation, the development of the trouble is to be traced to the way the whey is handled, especially in the factory itself.

The following suggestions will prove of value in restraining and preventing such a cheese defect as the one here described.

1. *The Whey Vat in the Factory.*—Where the whey is held for twenty-four hours to allow it to sour, so as to permit the butter fat to be more thoroughly skimmed, yeast organisms of this type are almost sure to develop in greater or less numbers. We have made an examination of a number of wheys of this type taken from different factories and such findings are quite common. If the butter fat left in the whey after the curd is taken out could be removed immediately or within a short time, no such development as this could take place. Such can be done by immediate separation of the whey in a cream separator. It has been conclusively demonstrated that the quality of the butter is enough better and the quantity secured enough larger to warrant the installation of machinery which will do this work. Of course, the installation of steam to furnish power could not economically be made in the smaller factories, but such a course would doubtless prove advantageous in the long run in the factories where a larger amount of milk is handled. The present custom of souring the whey is not nearly as satisfactory from this point in view as the now pretty generally discarded method of scalding the whey to get the butter fat.

*Mr. Marty informs us that there are at least ten factories in this district that are using the separator for skimming the whey.

2. *Soaking Whole Rennets in Whey.*—Nothing can be better suited to cause trouble than this custom of soaking the rennets in whey, if the whey is once contaminated with this yeast organism. Boiled or heated whey can doubtless be used with inpunity for this purpose, but the experience of Swiss makers has shown that the addition of the whey furnishes lactic acid bacteria which are in some way desirable for the process of manufacture. The use of commercial rennet extract would overcome this difficulty; as such rennet extracts are not likely to be contaminated in this way.

Considerable prejudice though exists in the minds of most makers against the use of commercial rennet extracts, but the experience of the Swiss diary schools is in favor of this method when combined with a pure lactic ferment.

If whole rennets are employed, heated whey should be used, and particular care should be given to the rennet jars which should receive a thorough sterilization at frequent intervals.

3. *Disposal of Whey to Farmers.*—The quicker the whey can be delivered to the farmers the less likely are troubles of this sort to develop. Much greater care should be given the receptacles in which the material is stored. If it is impossible to have a single receptacle because some individuals will take more whey than their share, the barrels, if used at all, should be so placed that they can be wholly emptied and kept in a clean condition.

Factory operators are urged to give especial heed to this relatively new type of cheese troubles. While the presence of this organism can be readily determined by miscroscopical examination of the whey, yet a simple method may be given which will enable the maker to know whether his whey is likely to contain the seeds of this disease. Take a sample of whey and cork it up tightly in a small bottle. Set it where it is warm (not in the sun) for several days. If gas does not develop abundantly on the first or second day, but does do so later (3rd or 4th day), it is good evidence that the trouble it due to this yeasty type of ferment. Yeast cultures also develop a great abundance of carbonic acid gas which can be quite readily detected by shaking the

whey vigorously. Where carbonic acid is abundant the liquid wilil foam violently upon agitation.

Dangers from this source would be entirely eliminated if a different repectacle than the can used for the fresh milk was employed to carry back the whey to the farm. Old, discarded cans that are not fit to use for the milk could be utilized for this purpose.

4. *General Disinfection of Factory.*—Of course, if a factory once becomes badly infected, it is necessary to take such restrictive measures as will destroy the organism in the factory. Our previous observations have demonstrated that the germ is resistant either in a dried or moist state and that no reliance can be placed on the action of time. Heat is naturally the most effective agent. If steam is at hand, even a momentary exposure is sufficient to destroy its vitality, but where reliance is had only on a scalding temperature (150°F.) it is necessary to prolong the period of exposure for at least ten or fifteen minutes. For washing the walls and floors of a factory a 2% solution of hot lye will prove effective.

SYNOPSIS OF BULLETIN.

The Swiss cheese industry is more apt to be troubled with abnormal fermentations than the cheddar industry, because the milk is worked up in a relatively sweet condition. In cheddar cheese, the development of lactic acid holds many of the gas-producing bacteria in check, thereby preventing defective conditions due to this type of germ life. This last year an unusual fermentative change was found in a Swiss cheese factory in Iowa county. Soon after the cheese were taken from the press, they began to crack open on the edges or sides in a manner quite different from the ordinary gassy fermentation. The cheese acquired an off flavor of a sweetish character and in many cases were utterly ruined. The loss in this one factory amounted to over $2,000.

Despite the best efforts of the maker who was a very successful operator, the trouble existed, until the close of the season. The investigation by the Experiment Station was begun late in the fall and it was soon found that the trouble was caused by a yeast which was able to ferment milk sugar, producing alcohol, carbonic acid and other by-products. Ordinarily, yeasts, like the bread and beer yeasts, do not act upon milk-sugar, but this germ grows rapidly in such sugar solutions and especially so, when the liquid is acid. Therefore, the conditions in old whey are ideal for its growth. Having found the cause of the trouble and demonstrated that it was capable of producing the abnormal fermentation described, attempts were then made to locate the way in which the factory came to be seeded with this particular germ.

In the Swiss cheese industry, several methods are followed that are more or less likely to produce trouble, as they give an opportunity for the growth of organisms that are capable of producting abnormal changes in milk or cheese. The three most important of these customs are as follows:

1 Barrel system of whey disposal to the farmers.

2. The "cold process" of recovering the butter fat to make

whey butter by allowing the whey to remain in vats until it sours and the cream rises by gravity.

3. Soaking the whole rennets in whey to extract the active curdling principle of rennet.

In the case of this particular factory, it was found that both the method of recovering the butter fat and the system of securing the rennet solution gave an opportunity for the introduction of the undesirable yeast germ.

The whey was placed in wooden vats for twenty-four hours so that it would sour. The cream was then skimmed off and churned into whey butter. When the factory was visited, the whey in the wood vat inside the factory was found to be in an active stage of fermentation. The cream that had been removed was covered with a frothy layer and smelled strongly of yeast. Where the whey was held until it soured, the conditions were most favorable for the growth of this yeast. This fermented material, taken back to the different farms by the patrons of the factory, had infected the several dairies supplying milk, so that this particular germ was found in the milk of every patron of the factory but one. The whole rennets were soaked in this infected whey to extract the active rennet used to curdle the milk. This rennet solution therefore was exceedingly rich in yeast germs, as was determined by bacteriological examination, and when this material was placed in the fresh milk, to curdle the same, it was practically adding an impure starter to the milk. The result could not be otherwise than a rapid development of an "off" condition in the cheese.

Since this outbreak was studied a second case of a similar character has come to light. Another factory in the same county, making block Swiss, was troubled in a similar way. The difficulty was overcome immediately by discarding the old method of soaking the rennets and using a commercial rennet extract.

It it in some such simple way as this that undesirable fermentative organisms are introduced into factories. Both maker and patron are apt to lay the blame on each other or claim any trouble produced is due to the poor quality of the milk furnished by the patron, or dirty conditions prevailing in the factory itself,

while as a matter of fact, the real source of trouble is generally some living ferment that finds it possible to develop abundantly in the milk through some carelessness in the way in which the milk is handled, either on the farm or in the factory. It is easily possible to overcome such troubles as this by handling the whey in such a way as not to permit it to sour and to give conditions favorable for yeast growth.

The old "hot process" of recovering the butter fat by heating the whey prevents in large measure the development of such germ life; also the much more modern method of immediately separating the cream from the whey by passing it through a cream separator. This custom enables the maker to recover all the butter fat and the quality of butter is far superior to that which can be produced by the methods now in vogue. In such a case the whey could be returned to the farmer in practically a sweet condition.

To overcome the danger of introducing undesirable germs in rennet extracts made by soaking whole rennets in whey, care should be used in selecting the whey for this purpose. If whey is first boiled, before the rennets are added, the danger is minimized, but the use of the commercial rennet extract would do away with troubles of this sort. This method was successfully used in the case of the second outbreak reported. If it was necessary to develop some acidity, as it is claimed, this could be done by the use of a little lactic ferment used in conjunction with the commercial extract. Greater care in such matters as this would doubtless do away with much loss which is now occasioned by the development of these microscopic foes that develop unseen in the milk.